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Summer Distribution of Juvenile Chinook and Coho Salmon within the Chignik River Watershed

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Cover Photo: Seasonal staff setting minnow traps for juvenile salmon in the Chignik River watershed, Alaska

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Daniel J. Rinella and Benjamin Rich

Abstract

We conducted a pilot project in 2016 to better document the basic biology of juvenile Chinook Salmon *Oncorhynchus tshawytscha* and to inform potential future work in the Chignik River watershed. We gathered data on their summer distribution, measured catch rates at various locations around the watershed to explore the feasibility of a future tagging study, and assessed the reliability of distinguishing juvenile Chinook Salmon from the more abundant Coho Salmon *O. kisutch* in the field. This work showed that the summer distribution of juvenile Chinook salmon covered much of the Chignik River watershed, although they appeared to be most consistently found in the lower watershed, from Chignik Lake to Chignik Lagoon. Intensive sampling in these areas suggested that concerted effort could feasibly sample hundreds of juvenile Chinook Salmon daily. Genetic analysis indicated that the field crew was able to reliably distinguish juvenile Chinook and Coho salmon, based on pigmentation of the adipose fin and the width and spacing of parr marks. This work has improved our understanding of the distribution of fish species and life stages around the Chignik River watershed and may facilitate future studies of juvenile Chinook Salmon by informing the logistics of capturing and identifying them.

Introduction

The Chignik River, on the Alaska Peninsula, drains Black and Chignik lakes southward to the Gulf of Alaska and supports all 5 North American species of Pacific salmon *Oncorhynchus* spp. Sockeye Salmon *O. nerka* dominate the runs numerically, have historically supported subsistence and large-scale commercial fisheries, and have been the subject of decades-long research and monitoring programs led by the Alaska Department of Fish and Game (ADF&G) and the University of Washington (UW). Chignik River's Chinook Salmon *O. tshawytscha* are rare by contrast and key aspects of their biology remain unexamined, including freshwater distribution and relative abundance.

ADF&G opportunistically gathers data on escapement and harvest of Chignik River Chinook Salmon

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because their run timing overlaps with that of Sockeye Salmon. Recent annual runs ranged from 1,547 to 10,177 fish (1978–2017), with an average of 5,466 (Schaberg et al. 2019). Most Chinook Salmon harvest occurs incidentally by commercial purse seiners targeting Sockeye Salmon in Chignik Lagoon and Chignik Bay, near the mouth of the watershed. This harvest averaged 1,894 fish (range = 208–5,240) and comprised 36% of the total run (range =11–72%) (1978–2017; Schaberg et al. 2019). Smaller numbers of fish are harvested annually in subsistence and sport fisheries (Schaberg et al. 2019). Run sizes have declined in recent years, and every run since 2006 has been below the long-term average (Schaberg et al. 2019). Runs in 2013, 2017, 2018, 2020, and 2021 run fell below ADF&G's biological escapement goal of 1,300–2,700 fish (Renick 2020; ADF&G Fish Count Data Search https://www.adfg.alaska.gov/sf/FishCounts/).

Existing data suggest that Chinook Salmon spawning distribution within the Chignik watershed is geographically limited. Prior to this project, ADF&G's Anadromous Waters Catalog (AWC) documented Chinook spawning only in the Chignik River (i.e., from the outlet of Chignik Lake downstream to Mensis Point, about 8 km). Ron Lind, a resident of Chignik Lake, reported to us that Chinook Salmon began spawning near his cabin on Black River around 2008, suggesting a recent expansion.

Prior to this project, the AWC contained no records of juvenile Chinook Salmon rearing in the Chignik watershed. Reports on Sockeye Salmon monitoring efforts by ADF&G and UW, however, provide some information on juvenile distribution. ADF&G conducted annual Sockeye Salmon smolt trapping on the Chignik River between 1994 and 2016 using rotary screw traps.

The most recent annual reports show small and variable (i.e., from 25–1,690 fish) annual incidental catches of juvenile Chinook Salmon (Finkle and Ruhl 2009; Loewen and Bradbury 2011; Loewen and Baechler 2015, 2016). These reports also show that daily counts tended to be higher during June and July than during May. Beach seining during May–July (2010–2015) in Black Lake and Chignik Lagoon, conducted in conjunction with ADF&G's Sockeye Salmon smolt trapping, captured low numbers of Chinook Salmon smolt during some years but not others (Loewen and Baechler 2016). Smolt trapping by UW indicates that Chinook fry are abundant in Chignik River from May through at least August (Ruggerone and Harvey 1994).

UW's beach seine data suggest that many of these fish migrate upstream to Chignik Lake during the fall and winter (Ruggerone and Harvey 1994). UW staff have also captured juvenile Chinook Salmon sporadically in Chignik Lake during annual May through August sampling (Westley et al. 2006).

ADF&G developed a Chinook Salmon Stock Assessment and Research Plan in 2013 to assess the causes and extent of Alaska's widespread Chinook Salmon declines over the prior decade. This plan, which focused research efforts on Chignik River Chinook Salmon and Alaska's eleven other index stocks, recommended stock assessment to estimate annual smolt abundance and, ultimately, allow calculations of marine vs freshwater survival rates (ADF&G Chinook Research Team 2013). The recommended work would use passive integrated transponder (PIT) and coded wire tags to estimate smolt abundance and marine survival from subsequent adult returns.

We conducted a pilot project in 2016 to collect data in support of potential future work on juvenile Chinook Salmon in the Chignik River. During this project, we gathered data on the summer distribution of juvenile Chinook Salmon within the Chignik River watershed, measured catch rates at various locations around the watershed to explore the feasibility of a future tagging study, and assessed the reliability of field characteristics for distinguishing juvenile Chinook Salmon from the more abundant Coho Salmon *O. kisutch*. Despite our focus on Chinook Salmon, we also report data for Coho Salmon captured during this effort.

Objectives

1. Document the summer distribution of juvenile Chinook and Coho salmon at sites throughout the Chignik River watershed accessible by jet boat and nominate any new occurrences of species or life stages to the AWC

2. Identify sampling sites, seasonal timing, and sampling methods with the greatest potential to yield large samples of juvenile Chinook Salmon for any future tagging studies

3. Confirm that juvenile Chinook and Coho salmon from the Chignik River watershed can be reliably distinguished in the field

Study area

The Chignik Watershed is a major salmon system on the Alaska Peninsula that drains southward into the Gulf of Alaska. The watershed contains two large lakes connected by rivers, Black Lake and Chignik Lake (Figure 1), which support genetically distinct runs of Sockeye Salmon. The Black River drains from Black Lake, which is surrounded by low-lying tundra near the center of the Peninsula, into Chignik Lake, a much deeper and narrower lake surrounded by mountains.

The Chignik River flows from the southern end of Chignik Lake (near the Village of Chignik Lake) into the brackish Chignik Lagoon. Chignik Lagoon and Chignik Bay, separated by a narrow spit, support most of the commercial fishing activity in the area.

Methods

To address objective 1, we sampled juvenile Chinook and Coho salmon throughout the Chignik River watershed late May–late July 2016, focusing our efforts on 5 zones: (1) Chignik Lagoon,(2) Chignik River, (3) Chignik Lake including tributaries, (4) Black River including tributaries, and (5) Black Lake including tributaries (Figure 1). Our sampling effort focused disproportionately on the Chignik River (Table 1) as we presumed this to be the primary spawning and rearing habitat and because wind-driven chop on Chignik Lagoon and Chignik Lake often prevented boat access to other parts of the watershed. Our primary gear was Gee- style minnow traps (Table 1) baited with commercially cured salmon roe and soaked for approximately 1 hour. In flowing water, we typically set minnow traps in areas of low current (e.g., pools, alcoves, behind boulders) while in the lagoon and lakes we set along the margins in water 30–100 cm

deep. We also sampled with a mini fyke net (12.3-m lead, set perpendicular to shore) in Chignik Lake and Chignik River and a Smith-Root LR-24 backpack electrofisher in Cucumber Creek (Table 1). During each sampling event, we used Pollard et al. (1997) to identify all salmonids and counted all fish by species.

For objective 2, we focused intensive sampling on the areas and techniques that we expected would yield the largest samples of juvenile Chinook salmon. This effort, which began in late July 2016 and extended through the end of sampling in late August, consisted of beach seining (30-m long, 10-minute tows parallel to shore) in Chignik Lake and Chignik Lagoon and baited minnow trap sets in Black River and Chignik River (Table 1). Because our earlier sampling indicated that catch rates were maximized in deeper water with stronger current than normally fished with minnow traps, we rigged the traps used in this effort in gangs of 4, tethered them to a 5-kg mushroom anchor marked by a buoy, and set them in areas with coarse substrate and moderate flow between 1 and 2 m deep.

For objective 3, we collected fin clips from a subsample of 404 fish identified in the field as juvenile Chinook or Coho salmon for genetic species confirmation by the USFWS Conservation Genetics Lab, preferentially selecting specimens that were difficult to distinguish. Prior to release, we also photographed the left side of most fish for future reference (n = 191 Chinook Salmon and 187 Coho Salmon).

Results

We caught juvenile Chinook Salmon in the Chignik Lagoon, Chignik River, Chignik Lake, Black River and in roughly half of the tributaries sampled (Table 1). We caught juvenile Coho Salmon at every site except a few tributaries to Black Lake and Black River.

These collections, and some incidental observations, led to several AWC nominations for species and life stages that had not been previously cataloged. We nominated Chignik Lake, Chignik River, Black River, Alec River, Bearskin Creek, Chiaktuak Creek, and Crater Creek for Chinook Salmon rearing. We confirmed Ron Lind's report of Chinook Salmon spawning in Black River near his cabin and made that nomination as well. We also nominated Chignik and Black lakes, Chignik and Black rivers, and 6 tributary streams for Coho Salmon rearing, 7 water bodies for Dolly Varden presence, and Chignik Lake and Chignik River for Sockeye Salmon spawning and rearing.

Our intensive sampling suggested that sampling Chignik Lagoon, Chignik Lake, and Chignik River during July and August had potential to produce large samples of juvenile Chinook salmon. August minnow trapping (n = 216) in Chignik River produced 2.9 fish per 1-hour soak, July beach seining (n = 2) in Chignik Lagoon produced 18 fish per 10-minute tow, and August beach seining (n = 38) in Chignik Lake produced 11.9 fish per tow (Table 1).

Genetic analyses of 404 fish identified in the field as juvenile Chinook or Coho salmon indicated that 95.6% were identified correctly while 2.7% were misidentified (genetic

identification was inconclusive for 1.7%).

Discussion

This work showed that the summer distribution of juvenile Chinook salmon covered much of the Chignik River watershed, although they appeared to be most consistently found in the lower watershed, from Chignik Lake to Chignik Lagoon. Our intensive sampling also suggested that they were most abundant in this area, at least during July and August, suggesting that the lower watershed may be the primary summer rearing area. Intensive sampling also suggested that concerted effort in the lower watershed could feasibly sample hundreds of juvenile Chinook Salmon daily.

Genetic analysis indicated that the field crew was able to reliably distinguish juvenile Chinook and Coho salmon. The most reliable diagnostic trait was the pigmentation of the adipose fin, with Chinook Salmon having an opaque chromatophore-free "window" and Coho Salmon having chromatophores throughout (Dahlberg and Phinney 1967; Pollard et al. 1997). With practice, the crew could quickly distinguish salmon species based on their overall appearance, which we assumed was based on differences in the width and spacing of parr marks.

As a follow-up analysis, we measured Chinook and Coho salmon parr mark width and spacing using the photographic archive of genetically confirmed specimens (Figure 2). Working along the lateral line, we digitally measured the width (in pixels) of each of the first 4 parr marks lying completely behind the gill plate and the 3 gaps between them (in addition to fork length of each fish) and expressed the width of each parr mark and gap as a proportion of the respective fish's fork length. We then measured pairwise correlations between all 7 features and used those that were uncorrelated ($r < 0.60$) as predictors in a linear discriminant function to determine if they could accurately assign species. In this model, the species of each individual (i) was assigned based on 3 predictors: the width of the first parr mark, the space between parr marks 1 and 2, and the space between parr marks 3 and 4:

$$Species_i \sim Parr\_1_{xi} + Space\_1\_2_{xi} + Space\_3\_4_{xi}$$

We fit the model to a randomly selected 75% of the data, used the resulting model to assign species to the remaining 25%, and repeated 1,000,000 times to calculate mean (and 95th percentile) accuracy rate. We used the function lda in package MASS using R (v.4.0.2, R Core Team 2020) to fit the model and used the predict function for calculating posterior probabilities. The model assigned Chinook Salmon with 74% (95th percentile = 62–85) accuracy and Coho Salmon with 81% (95th percentile = 0.68–0.92) accuracy, indicating that parr mark width and spacing alone could correctly assign species most of the time.

This work has improved our understanding of the distribution of fish species and life stages around the Chignik River watershed. Additionally, it may facilitate future studies of juvenile Chinook Salmon within the watershed by informing the logistics of capturing and identifying them.

Acknowledgments

Adam Grunwald served as the field crew lead and made digital measurements of parr mark width and spacing. Field housing and logistical support were provided by ADF&G's Division of Commercial Fisheries and UW's Alaska Salmon Program. In particular, we thank Dawn Wilburn, Lucas Stumpf, and the rest of the ADF&G weir camp plus Jeff Baldock and Dean Freundlich from UW's field camp. We also thank the residents of Chignik Lake for their help and hospitality and Ron Lind for sharing his knowledge of local salmon populations. Editorial review of this report was provided by Jonathon Gerken and Mike Buntjer.

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Table 1. Sampling effort and catch, by sampling location, month and gear type. Effort is expressed in 1-hour sets for minnow trapping, by the number of 10-minute tows for beach seining, by number of sets (and cumulative hours) for mini fyke netting, and the cumulative shock time for electrofishing. Catch rates are not necessarily comparable across rows due to differences in sampling gear and effort.

Zone	Location	Month	Gear type	Effort	Chinook catch	Coho catch
Chignik Lagoon	Chignik Lagoon	July	minnow trap	54	40	0
	Chignik Lagoon	July	beach seine	2	36	4
	Chignik Lagoon	August	beach seine	23	32	268
Chignik River	Chignik River	May	minnow trap	28	22	21
	Chignik River	June	mini fyke net	1 (9 hours)	0	199
	Chignik River	June	minnow trap	43	8	49
	Chignik River	July	minnow trap	168	224	222
	Chignik River	August	minnow trap	216	629	318
Chignik Lake	Bearskin Creek	June	minnow trap	30	1	18
	Chignik Lake	June	mini fyke net	5 (88 hours)	52	342
	Chignik Lake	June	minnow trap	79	44	122
	Chignik Lake	July	minnow trap	41	0	28
	Chignik Lake	August	beach seine	38	453	2530
	Clark River	June	minnow trap	29	0	24
	Clark River	July	minnow trap	12	0	0
	Cucumber Creek	May	minnow trap	4	0	0
	Cucumber Creek	June	electrofisher	1264 seconds	0	15
	Home Creek	May	minnow trap	15	0	88
	Home Creek	June	minnow trap	25	0	3
Black River	Black River	June	minnow trap	25	4	161
	Black River	July	minnow trap	26	2	37
	Black River	August	minnow trap	160	30	197
	Chiatkuak Creek	June	minnow trap	2	2	8
	West Fork	June	minnow trap	5	0	0
Black Lake	Alec River	June	minnow trap	23	6	52
	Black Lake	July	minnow trap	20	0	2
	Crater Creek	June	minnow trap	3	1	10
	Fan Creek	June	minnow trap	3	0	0
	Milk Creek	June	minnow trap	3	0	0

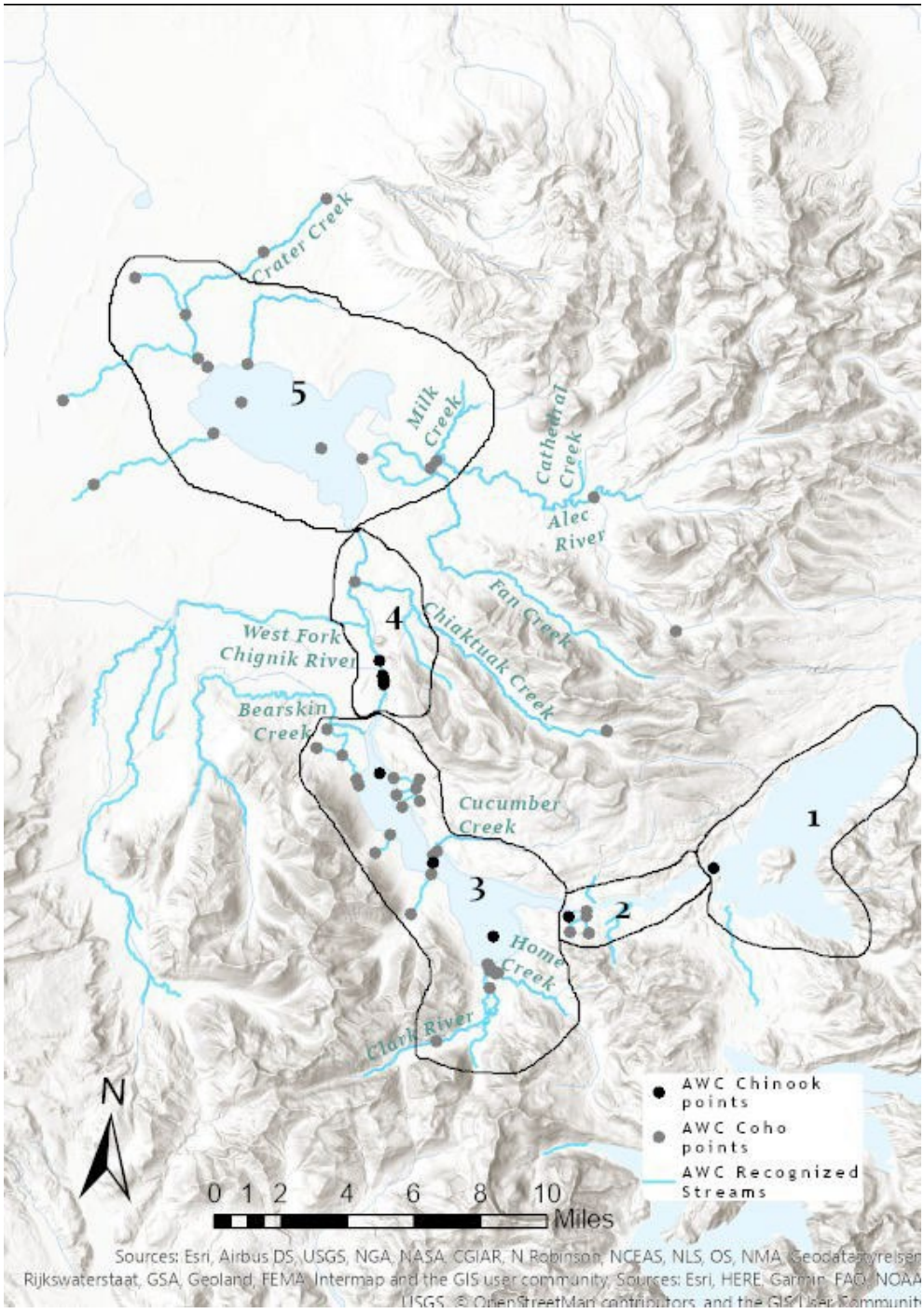

Figure 1. Map of Chignik Watershed showing all cataloged anadromous waters and points on water bodies cataloged for Chinook and Coho salmon. The sampling zones used in this study are outlined in black: (1) Chignik Lagoon, (2) Chignik River, (3) Chignik Lake and tributaries, (4) Black River and tributaries, (5) Black Lake and tributaries.

Figure 2. Examples of field photographs of juvenile Chinook (top) and Coho (bottom) salmon used to measure width and spacing of parr marks. The yellow box outlines the 4 parr marks and 3 gaps used in our analysis, which showed that Chinook Salmon had wider parr marks and narrower gaps (as a proportion of body length) than Coho Salmon.